Shale Gas: Controversies Explained

by Engr. Khor Cheng Seong

THE shale gas revolution has transformed the global energy scene, especially in the United States of America (USA). Today, shale gas is responsible for about 34% of the total natural gas production of USA with an expectation that it could reach as high as 60% by 2035 - an amazing feat given that its contribution was only 1% a decade ago. This rise to prominence has also resulted in the USA trumping Russia as the world's largest gas producer. Closer to home, our national oil company, PETRONAS, has recently acquired a company with shale gas assets in Canada. There is however no known shale gas resource in Malaysia.

WHAT IS SHALE GAS?

Shale is the original source rock for oil and gas, where vegetation and microorganisms have been deposited. Shale can contain oil or gas and, particularly in the USA, shale oil is also important. Despite its new-found value and role, shale gas has not been shy of controversies. In the carbon-constrained world that we live in now, it has its own share of detractors.

WHAT IS THE FRACKING PROBLEM?

A major issue concerns the environmental and possible seismic impacts of shale gas production. At the centre of attention is hydraulic fracturing, also known as hydrofracturing or simply fracking, which is one of the two main technologies that have been instrumental in economising shale gas extraction, the other being horizontal drilling. Figure 1 shows a schematic of typical shale gas production operations.

WHAT DOES FRACKING DO?

Fracking conventional oil reservoirs (which are mainly made up of porous sandstone) to improve production has been a common practice for many years since its introduction around 1903 and commercialisation around 1949. It is usually performed in a way so as not to frack the shale rock, which is the cap rock acting as a seal to trap the oil or gas underneath (and of several orders of magnitude less porous).

Fracking shale is more difficult since it is stronger and less brittle. Only in the last 10 to 20 years have the techniques been developed to enable shale to be fracked with confidence. The aim is to fracture the shale (which may not be very deep) but not the surrounding strata. If this can be achieved, the risk of direct leakage of methane or fracking fluid through the cracks to drinking water sources (e.g. aquifers) near the surface should be minimal. Like most of the other concerns raised, it is a matter of good management in designing the fractures properly. Developers have very detailed knowledge of the strata immediately around the well, though knowledge of the field as a whole is less detailed, but the quality of seismic data continues to improve over time.

Each well has several concentric tubes that form the well casings, more as it gets closer to the surface, and these are grouted in with concrete. This should prevent any leakage of methane gas or petroleum liquids to the surface around the well. However, cracks do occur in the grouting with time and with impact of the fracking. Thus, it is important to have a good quality grouting and regular monitoring.

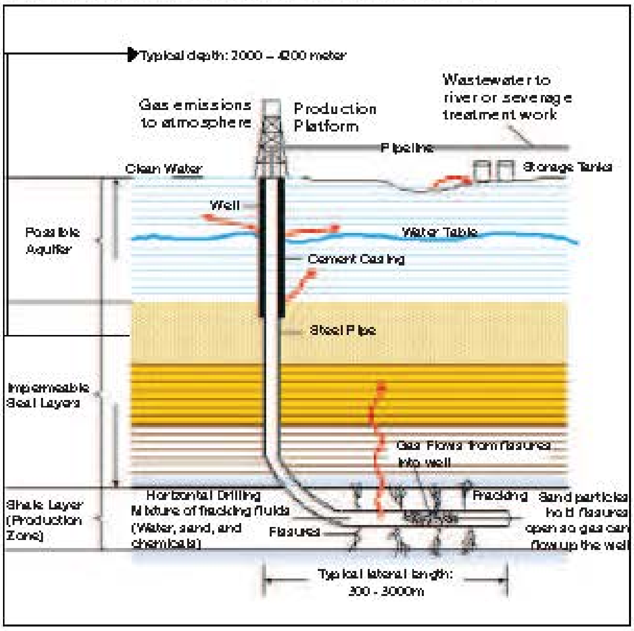

Figure 1: Schematic of shale gas production operations with horizontal drilling and fracking

IS FRACKING FLUID HARMFUL TO HEALTH?

Fracking fluid consists mainly of a water-soluble polymer gel called guar which is derived from wheat, and is harmless, and even safe if one accidentally consumes it. However, to improve its viscosity, small quantities of "cross-linkers" are added into it which sometimes include toxic metals such as chromium, zirconate, or titanium; at one time, even napalm. But there are a lot of other options, and it is generally believed that it is quite possible to use only harmless materials.

IMPACT OF FRACKING ON WATER RESOURCES

A lot of water is needed in fracking, and it returns to the surface heavily contaminated. Most are treated, while some can be re-used but only after blending with clean water since it is so contaminated. Cleaning the returning water up to usable standards would be costly.

Possible water pollution due to fracking is perhaps the issue that has received the widest public attention. However, no conclusive result has yet to be found from available studies that fracking causes methane contamination of drinking water. Although such a possibility remains, other ways that methane from shale gas wells could end up in groundwater (which is the main source for drinking) include leaky well casings due to poor well design and operation, gas migration due to leakage from abandoned wells, and even naturally occurring methane. In any case, it is clear that good well design practices are crucial (Osborn *et al.*, 2011).

METHANE EMISSIONS FROM GAS PRODUCTION

A second major issue in shale gas production pertains to uncontrolled (or fugitive) emissions of methane gas through leakage and venting. Methane is the main content of the shale gas produced and is a greenhouse gas (GHG) with global warming potential. The concern is to what extent the fugitive emissions result in higher lifecycle GHG emissions (or GHG footprint) for shale gas production as compared to conventional natural gas. The next question is whether or not the fugitive emissions are more than the proven carbon emission savings from the use of shale gas rather than coal. The latter, if affirmed to be true, renders shale gas as not cleaner burning than coal (on a lifecycle basis).

The issue gained attention in a 2010 report by the Environmental Protection Agency of the USA (EPA, 2010) that approximately doubled the EPA's earlier estimates back in 1997 on methane emissions from the oil and gas industry. The main components of this very large increase were the estimated methane releases from gas well venting for liquids unloading, which were the gases needed to remove (or blowdown) liquids that gradually build up and block flows in the wells.To elaborate, wells have to be vented when the well is completed in order to remove mainly the fracking fluids, and after a period of production, to remove liquids and rubbish that may have accumulated around the well. Moreover, methane venting is needed if the well is to some extent "wet", i.e., containing petroleum liquids besides gas. Technically, it would be quite possible to design a processing equipment using the so-called green technologies so that the methane is captured and separated for commercial use rather than vented to air. But this would also be quite costly.

In December 2011, the USA Argonne National Laboratory published its analysis of GHG emissions from the gas industry using the new EPA data. They concluded that 1.19% of shale gas production and 1.93% of conventional gas production escaped to the atmosphere (Burnham *et al.*, 2012). The findings suggest that less methane may be vented from shale gas production than that of conventional gas. This is because the shale deposits being developed are typically dry and do not yield much in the way of liquids. This is quite plausible: the shale deposits themselves vary all the way from dry gas to wet gas and shale oil.

SHALE GAS VERSUS COAL: WHOSE GHG EMISSIONS ARE HIGHER?

The Argonne study also found that considering a 100-year time scale for greenhouse impact, that the GHG footprint of shale gas is about 60% that of coal. They acknowledged a significant range of uncertainty, but not sufficient to achieve anything like parity between shale gas and coal.

On the contrary, an earlier study by researchers at Cornell University (Howarth *et al*., 2011) came to rather different conclusions that shale gas emissions are comparable to those from coal, exceeding them in their upper limit case on a 100-year time frame, while being substantially greater than coal on a 20-year time scale. Such finding went on to undermine the logic of shale gas use as a bridging fuel over the coming decades as we transition towards a low-carbon way of life.

The Argonne study criticised Howarth et al. on several grounds. These include their estimates of total lifetime production per well, emissions during delivery, emissions during flowback of fluids out of the well to the surface, and the allowance made for emissions reduction through recovery technology. Since then, numerous reports have been published with most bordering on the side of Argonne's findings.

Nevertheless, as the industry is relatively still in its infancy phase, it is difficult to draw hard conclusions. Clearly, methane emissions are much more significant than had been realised. They may significantly erode the mitigation advantages of both conventional and unconventional gas over coal. But the uncertainties are considerable and more studies are required. Of course, historical data of USA is not necessarily indicative of what would happen in new shale gas plays, or in the USA in the future for that matter. A further report is due from the EPA later.

TECHNOLOGIES TO REDUCE EMISSIONS

The current state of debate brings us to what may be the most important point for practitioners and investors alike. Plainly, there are technologies for reducing these emissions, which are widely known as reduced emissions completions (REC).

Apparently the USA Natural Gas STAR programme aims to do this and, according to Argonne, it was due to the total methane reductions claimed under this programme exceeded hitherto reported emissions that the EPA revised its inventory. According to the United Kingdom's joint Royal Society and Royal Academy of Engineering (2012) report on shale gas production, "... Green completion technologies [for shale gas production] could allow emissions levels similar to those associated with natural gas extraction. The EPA has issued federal regulations making green completion technologies mandatory for hydraulic fracturing of all gas wells in the USA from 2015 onwards." It goes on to recommend the consideration of similar regulation for the UK.

However, an interesting question that arises is how realistic it is to assume that these green technologies could make a big difference to methane emissions from future shale gas production in the USA, the UK, or China, the latter of which boasts of the largest shale gas resources in the world.

One rather bleak postscript: methane emissions from coal mining are, of course, also a rather complex element in the equation. According to Argonne, methane recovery from coal mines has been increasing rapidly in the USA until the early 2000s' but has now levelled off due to lower gas prices, which have offset coal use.

CONCLUSION

There are environmental and GHG emission concerns associated with shale gas production, but they are not dissimilar from conventional oil and gas production or any other industry for that matter. Proper well design and construction are crucial, so are the good production practices to ensure well integrity, coupled with prudent management of wastewater and other wastes alike. The environmental impacts can be mitigated with existing technology as with the emissions. Regular monitoring and implementation of suitable regulations are necessary to avoid significant local environmental damage.

ACKNOWLEDGEMENT

C. S. Khor would like to thank Neil Hirst for the initial materials that have led to this article while Khor was a researcher at the Grantham Institute for Climate Change of Imperial College London. ■

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